The impact of storage conditions on the forest biomass quality for biofuels production

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Bioenergy II – From biomass to chemicals and fuels – Rio de Janeiro, March 8th to 13th 2009

Outlines

- ✓ **Technological Institute FCBA**
- ✓ **Introduction**
- ✓ **Modalities of storage**
- ✓ **Biomass quality properties**
- ✓ **Effect of storage and potential of impact on process**
- ✓ **Conclusions**

FCBA

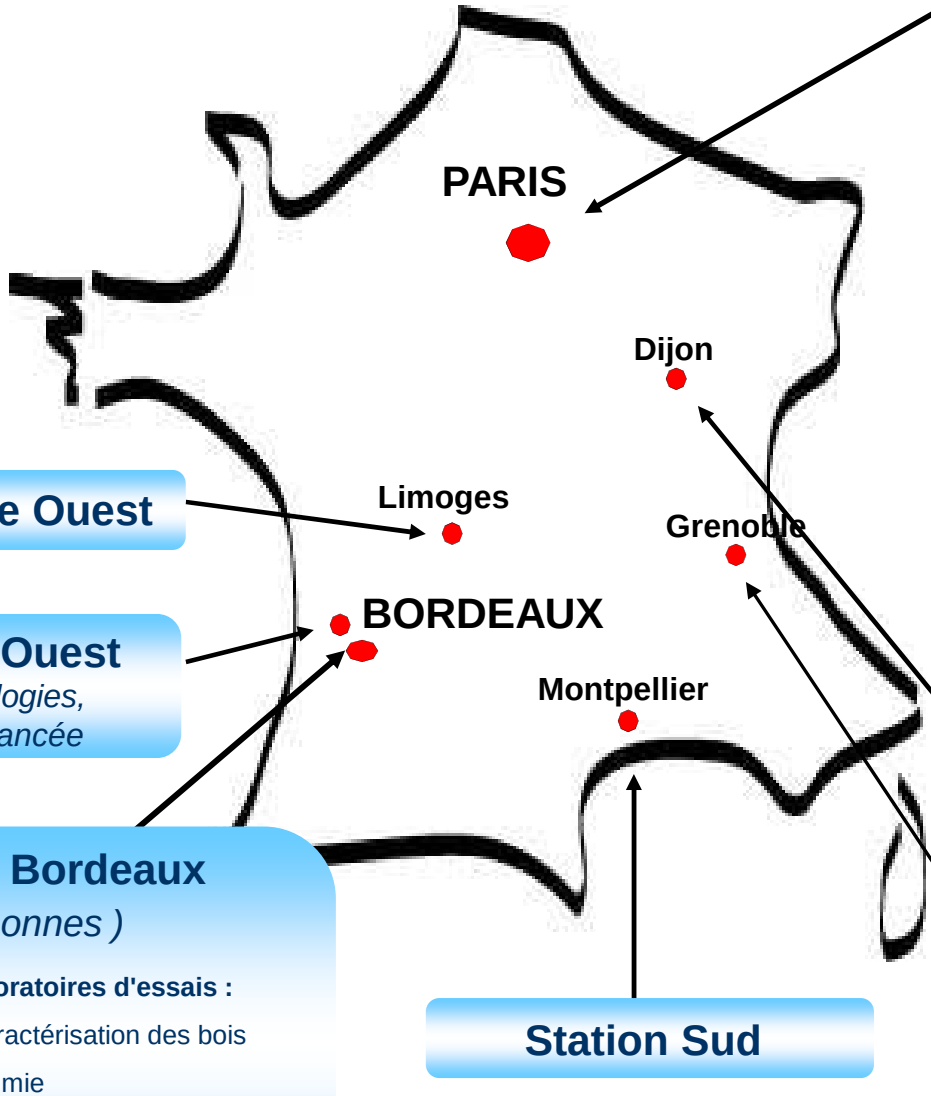
Forêt, Cellulose, Bois-construction, Ameublement
(Forest, Cellulose, Wood-construction, Furniture)

350 employées...

- Engineers
- Technicians
- Support teams

Technical center devoted to forest-products, pulp and paper, wood, housing, and furniture sectors.

Our locations



Siège Social Paris
(150 personnes)

- Première transformation, approvisionnement
- Ameublement
- Environnement, santé
- Economie, énergie, prospective
- Direction clients, formation
- Direction innovation, recherche *(veille techno. documentation)*
- Services généraux
- Bureau de normalisation
- Direction qualité
- Direction générale

Station Centre Ouest

Station Sud Ouest
Pôle Biotechnologies, Sylviculture Avancée

Station Nord Est

Site Boutaut Bordeaux
(130 personnes)

Pôle IBC :
- Structure
- Charpente
- Menuiserie
- Panneaux
- Préservation

Laboratoires d'essais :
- Caractérisation des bois
- Chimie
- Biologie
- Mécanique
- Physique

Station Sud

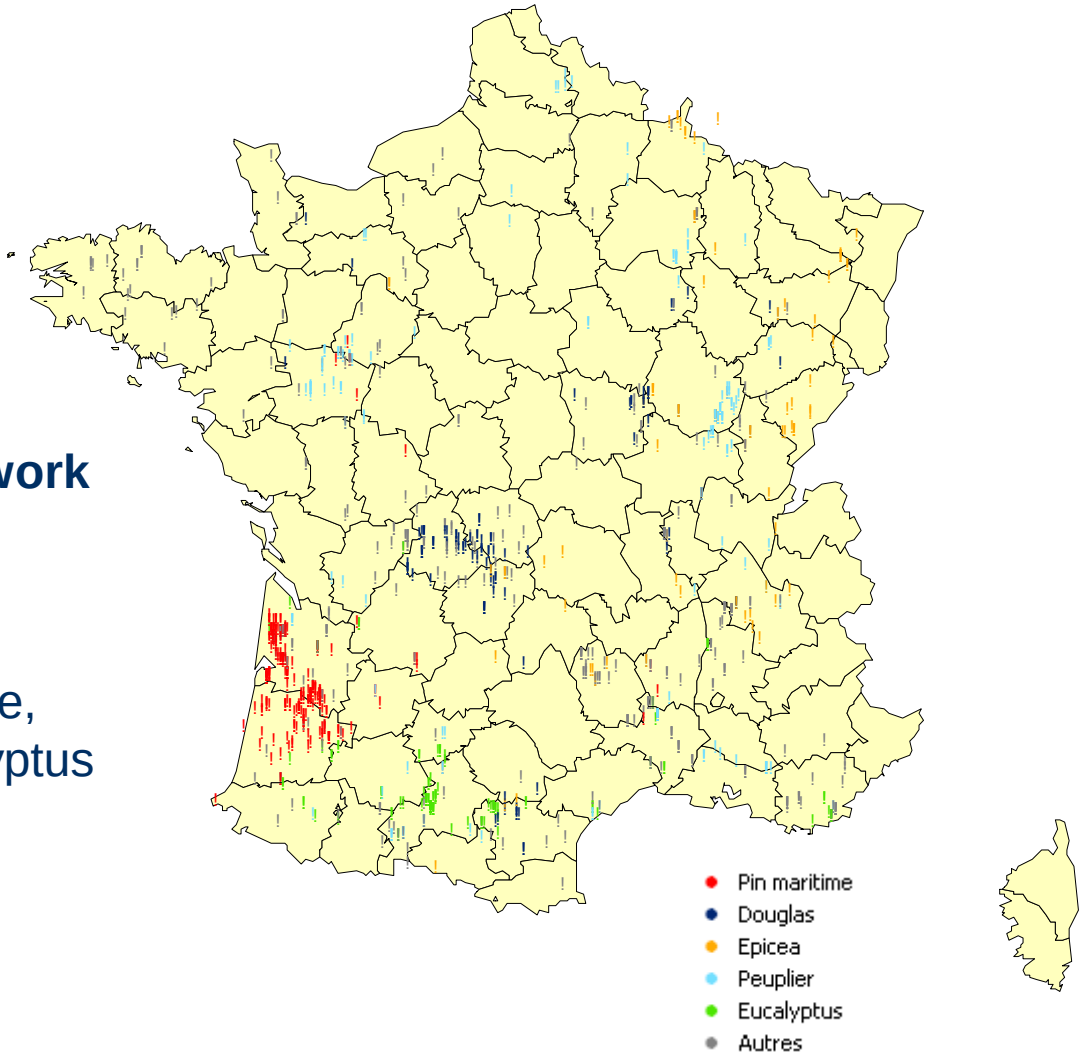
Pôle Nouveaux Matériaux
InTechFibres -

Field trial plantations network

- **A very important field trials network**

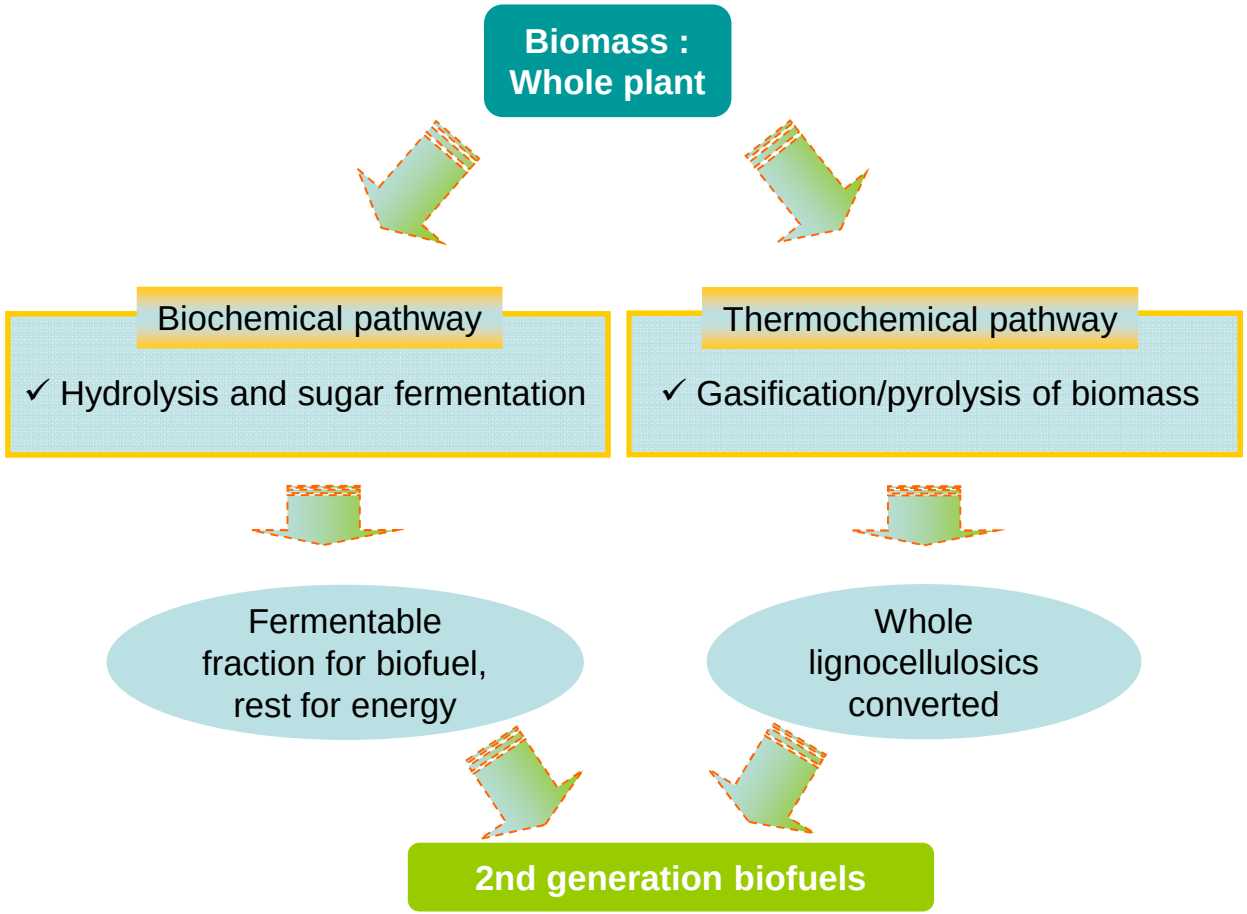
  1000+ trials
  ~ 1130 ha environ.

  Different wood species : spruce, Douglas-fir, pines, poplar, eucalyptus



Introduction

Second generation biofuels



- ✓ **Second generation biofuels uses the whole plant;**
- ✓ **Main difference between biochemical and thermochemical pathways is the needs of sugars « individualisation » for fermentation**

Introduction

Biomass quality

French REGIX project
Biomass and process people

- **FCBA (forest/wood)**
- **GIE ARVALIS&ONIDOL (agriculture)**
- **INRA (agriculture/forest)**
- **UCFF (forest/wood)**
- **CEA (thermochemical conversion)**
- **EDF (thermochemical conversion)**
- **IFP (thermochemical and biochemical conversions)**

List of biomass quality criteria and Identification of processes sensitivity

Composition

- C,H,O,N,S (T, B)
- Organic : cellulose, hemicellulose (monosucres), lignin,
- extractives (B)
- Volatiles, carbon, ash (T)
- Inorganics : ash, Cl, K, Na, F, P, Si, Ca, Mg ...(T)
- Humidity (T, B)

Morphology

- **Apparent density** (T, B)
- Particules size (T, B)
- **S**pecific surface (T, B)
- Porosity (T, B)
- Fines content (T, B)

Physical properties

- Thermodynamical data (PCI, CP) (T)

Data compilation and acquisition

- **Compilation of existing public data**
- **Complementary analysis for database completion**

Biomass storage

- ✓ **Supply chain requirements**

- ✓ **Seasonal production**
  - ✓ **Agriculture : cultures produced at different seasons**
  - ✓ **Forest : avoiding the presence of leaves for some hardwoods**

- ✓ **Reducing humidity prior transportation (environmental issues)**

- ✓ **Reducing humidity prior processing (technical issues)**

- ✓ **Different storage methods :**
  - ✓ **On production or processing site**
  - ✓ **Open-air or covered**
  - ✓ **Dry or under sprinkling**
  - ✓ **Silos**
  - ✓ **Etc**

- ✓ **Can storage help to adapt biomass quality to processes specifications ?**

Modalities

Different storage conditions :

- Open-air (forest environment), covered and water sprinkling

-2 seasonal periods

- Spring-summer and autumn-winter

-3 wood species

- Hardwoods (chestnut and poplar) and softwoods (maritime pine)

-2 forest products :

- Classical forest wood chips for chestnut (~ 40 years old) and (very) short rotation forests (2-4 y/o for pine and 2-7 y/o for poplar)

Spring-summer time

Storage method	Hardwoods chips		Softwoods
	Chestnut (classical forest)	Poplar (SRC/VSRC)	Maritime pine (2-4 y/o
Open-air	March 2007	April 2007	May 2007
Covered	March 2007	April 2007	May 2007
Water sprinkling	March 2007		May 2007

Autumn-winter time

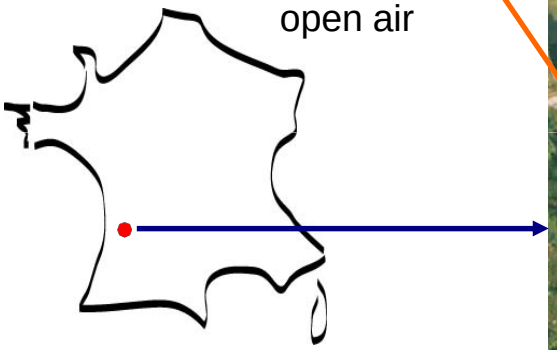
Storage method	Hardwoods chips		Softwoods
	Chestnut (classical forest)	Poplar (SRC/ VSRC)	Maritime pine (2-4 y/o
Open-air	October 2006		October 2006
Covered			
Water sprinkling			

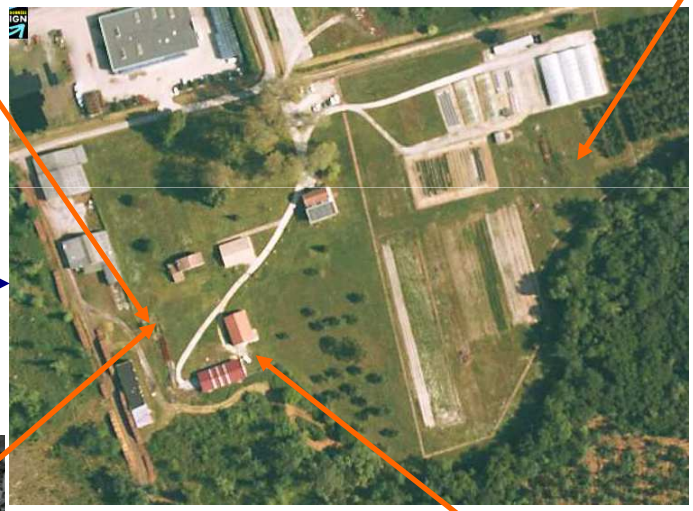
Modalities studied

Modalities installed at Sivaillan station

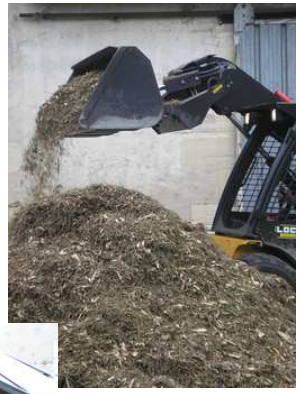
Softwoods,
open air

Softwoods,
water sprinkling



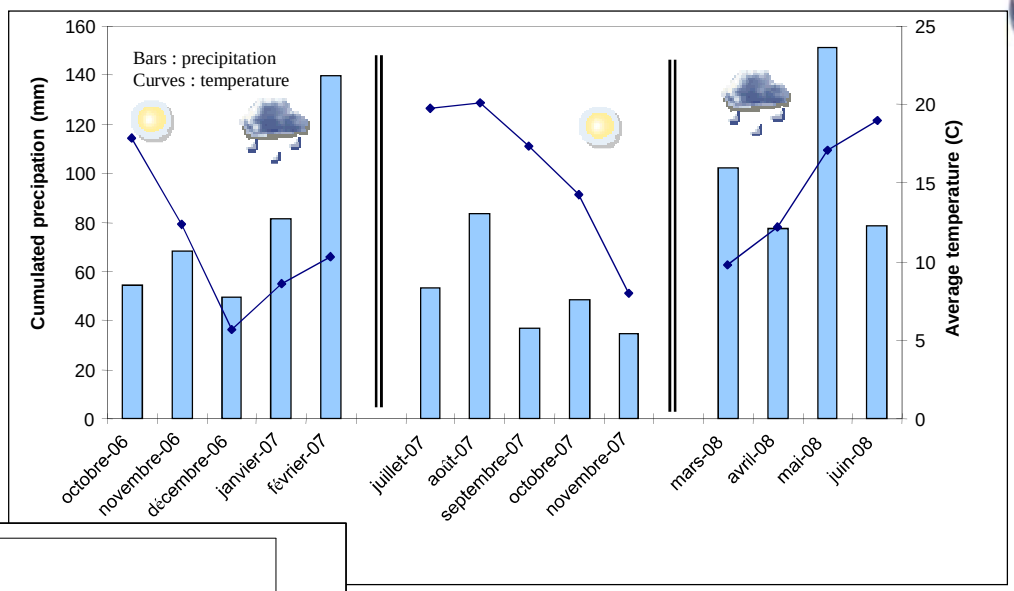


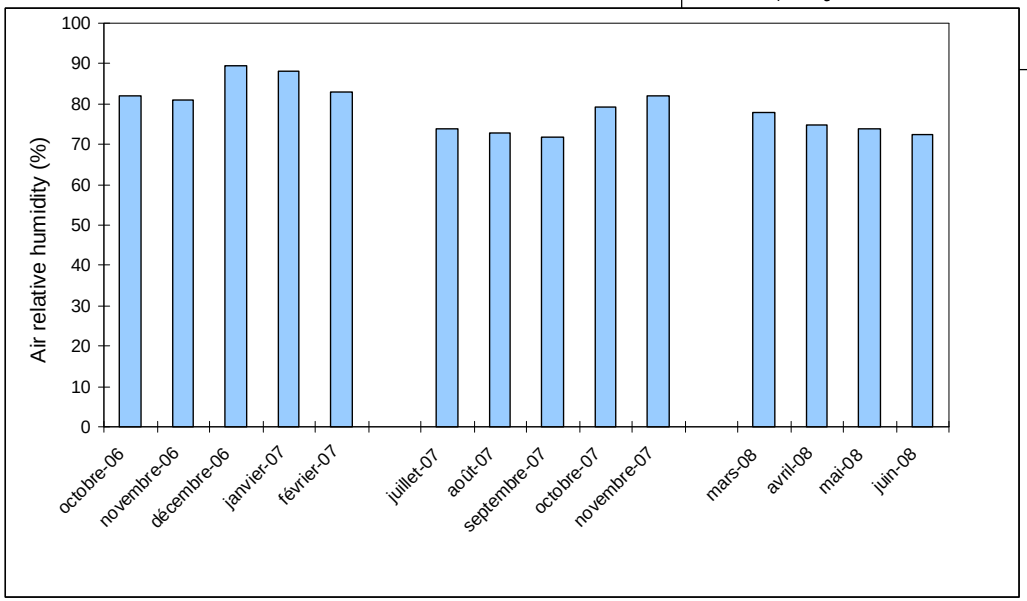
Hardwoods,
open air

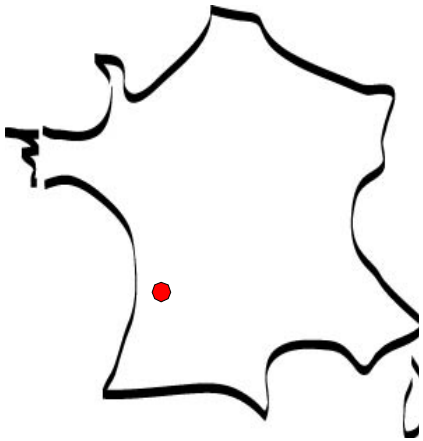


Softwoods,
covered

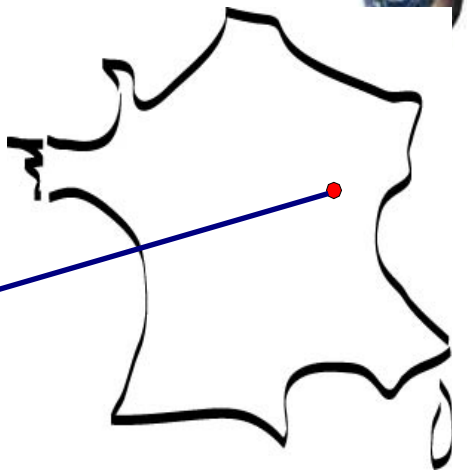
Meteorological data at Sivaillan station





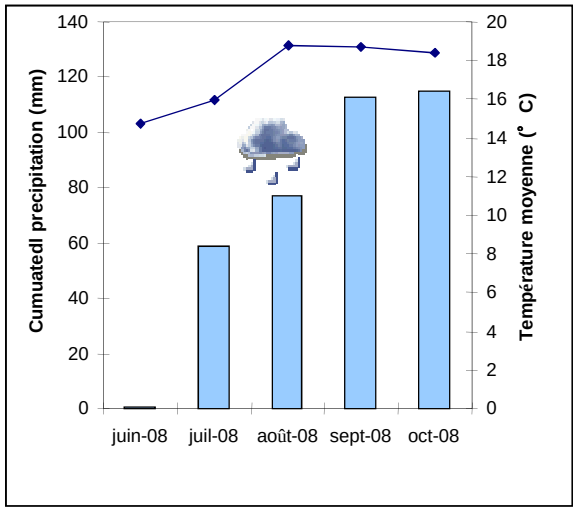


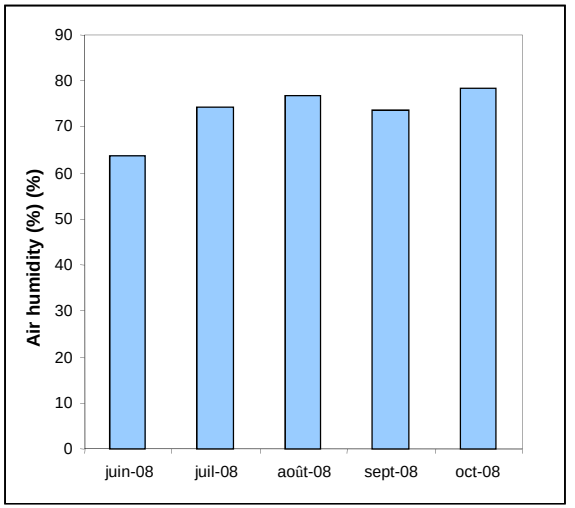
Modalities installed at Charrey station

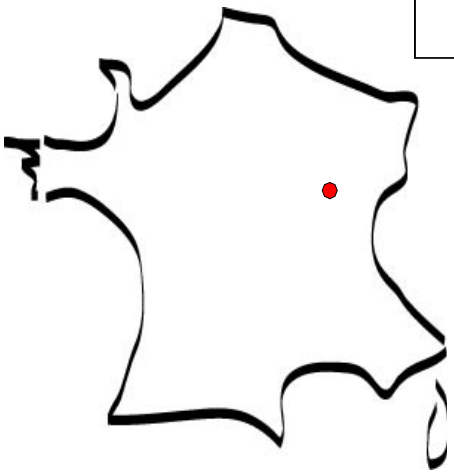


Hardwoods, open air and covered

Meteorological data at Charrey station

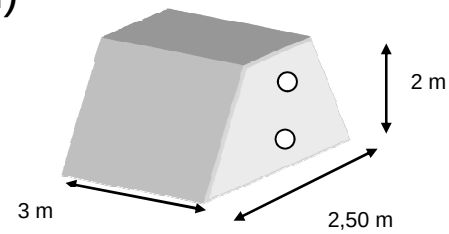






Modalities and frequency

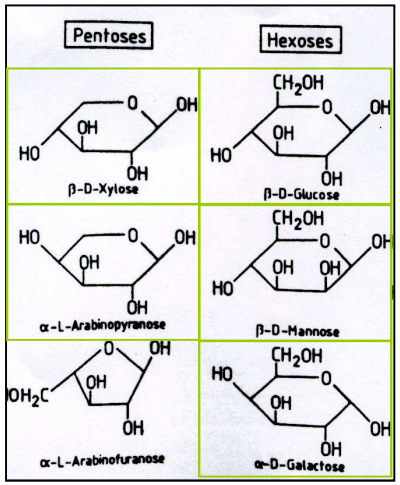
- ✓ 33 lots of wood chips sampled and conditioned in permeable bags attached to ropes.
- ✓ 3 bags analyzed for initial storage biomass
- ✓ 15 bags placed in the low part of the pile (0,50 m) (bottom)
- ✓ 15 bags placed in the high part of the pile (1,50 m) (top)
- ✓ 6 series studied at different storage times :
  0 d, 15 d, 1 m, 2 m, 3 m and 4 m.
- ✓ For each series, 3 bags removed and analyzed



10 m³ apparent
2.5 – 3.5 tons de wood / pile.



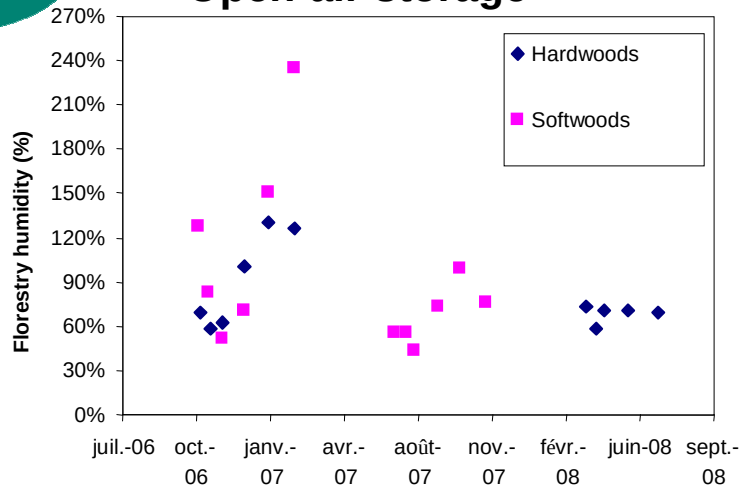

Biomass quality parameters

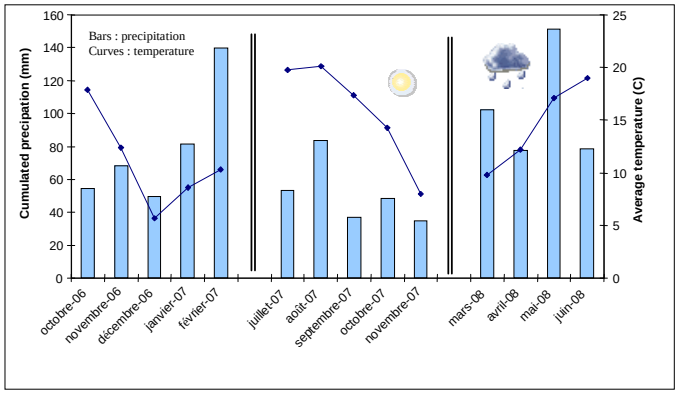


- ✓ Humidity (forestry : mass of water / mass of dried solids)
- ✓ Elemental analysis
  - ✓ C, H, O, N, Cl, S
- ✓ Chemical composition
  - ✓ Extractives content (water, acetone)
  - ✓ Lignin content
  - ✓ Cellulose content
  - ✓ Hemicelluloses content
  - ✓ Sugars analysis
    - ✓ Pentoses (xylose, arabinose) and hexoses (glucose, mannose, galactose)
- ✓ Ash content and composition (SiO_2, CaO, MgO, K_2O, Na_2O, SO_3, P_2O_5, MnO_2)
- ✓ Heating value (HHV)

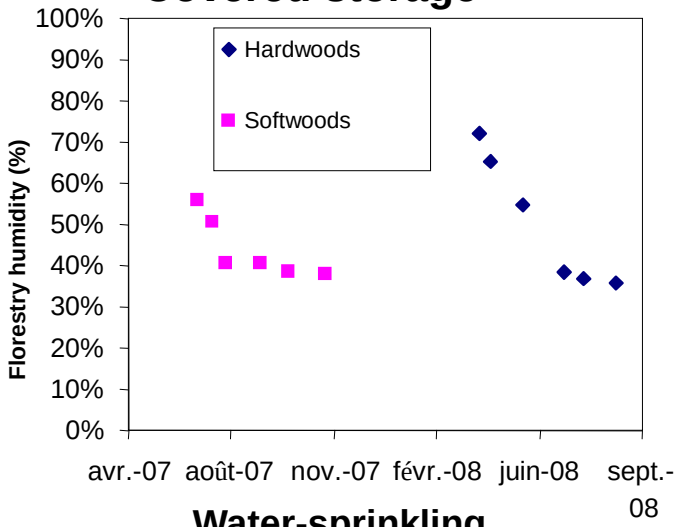
Humidity evolution

Open-air storage

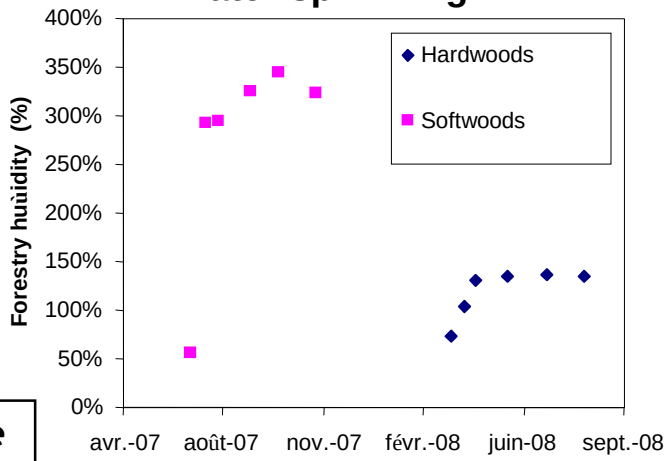




Covered storage

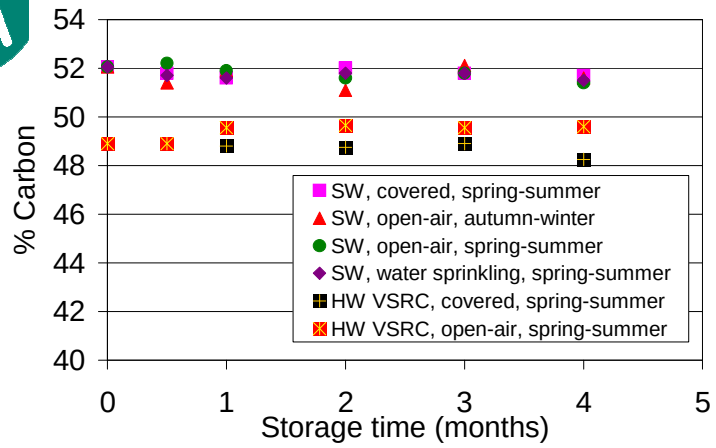


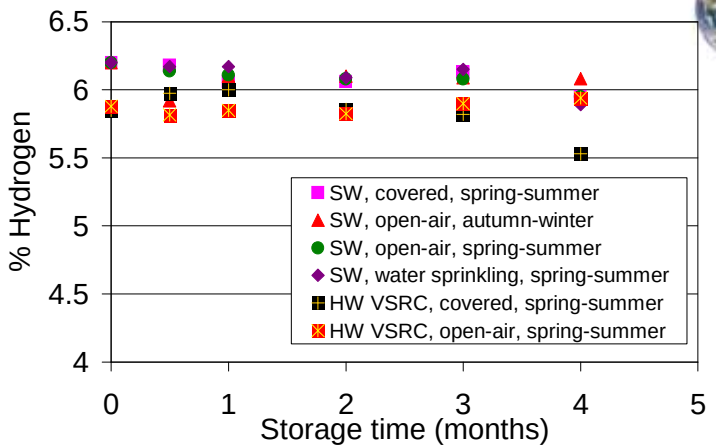
Water-sprinkling

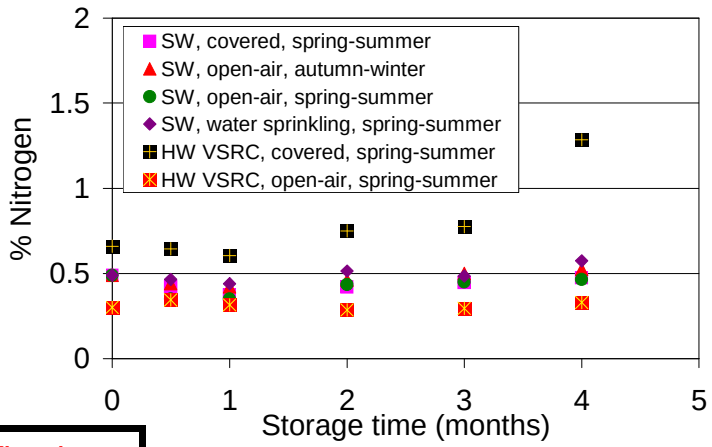


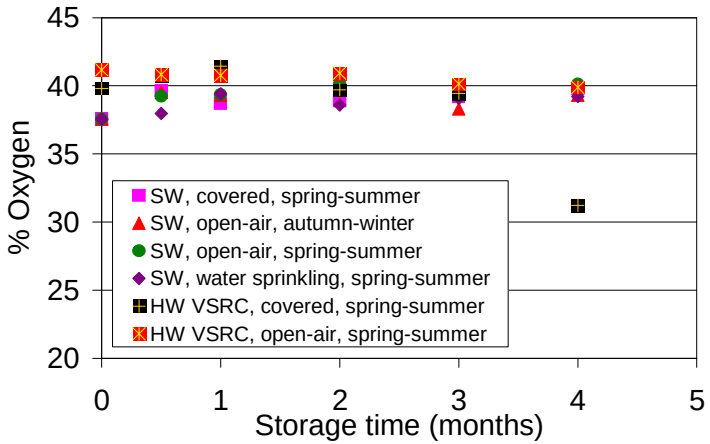
- ✓ Climatic conditions strongly impact open-air storage
- ✓ Covered storage allows slow drying (fungi activity)
- ✓ Water-uptake very different for SW and HW

Elemental analysis





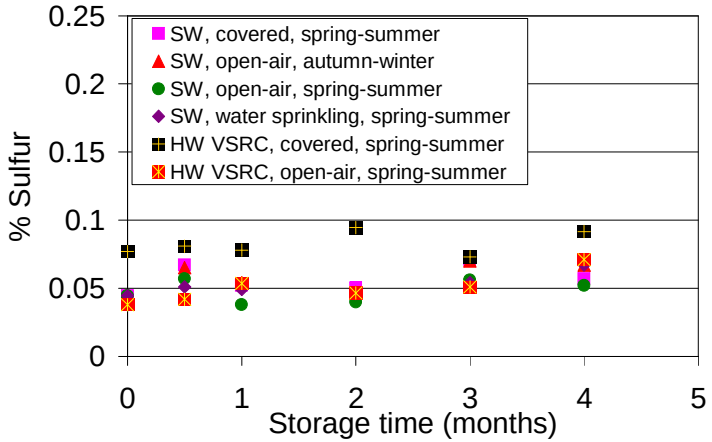


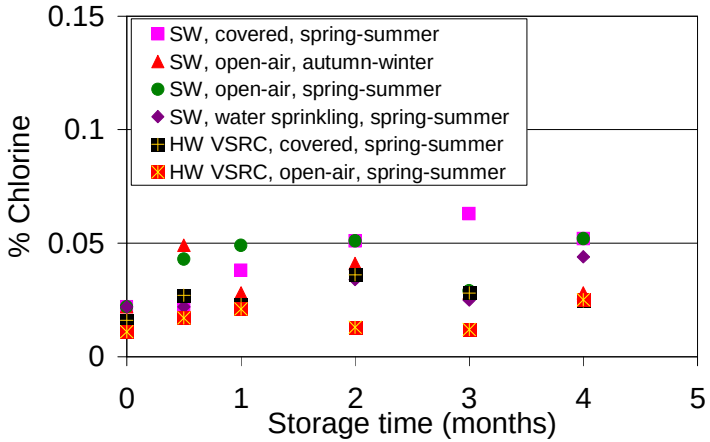


Process specifications (thermoconversion)	
C	**46 à 52 %**
H	**5 à 7 %**
O	**40 à 46 %**
N	**< 0.2 %**

- ✓ **Process specifications respected for C and H, but not for N and O**
- ✓ **Covered storage leads to C, H, O reduction while N increases**
- ✓ **HW more affected than SW**

Elemental analysis

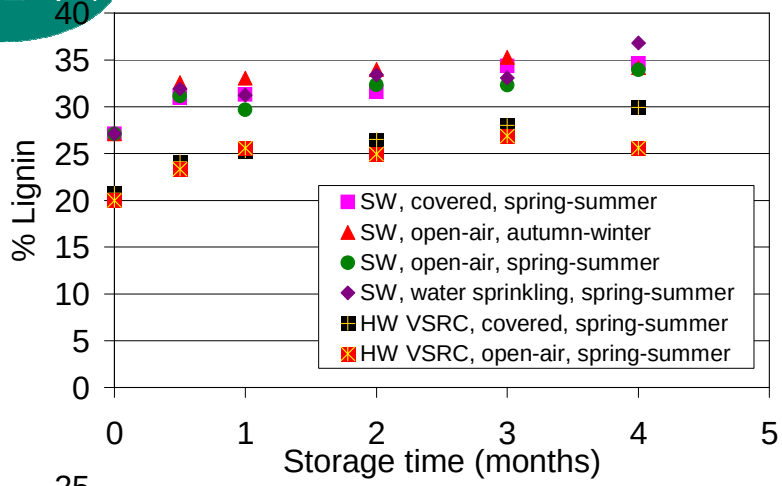


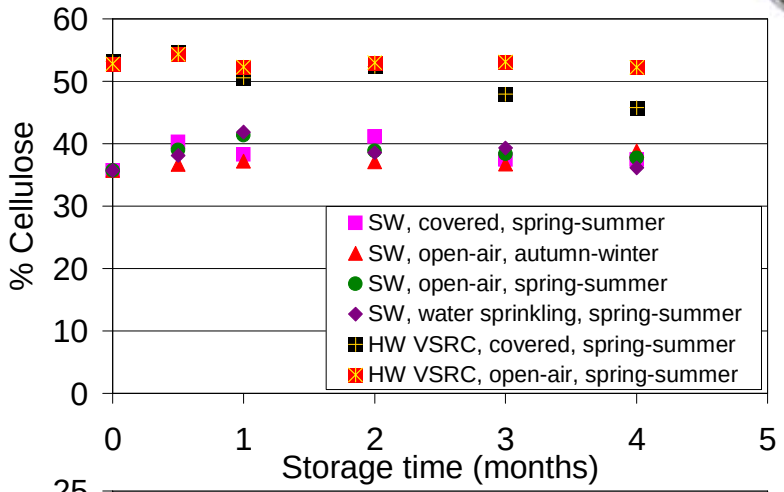


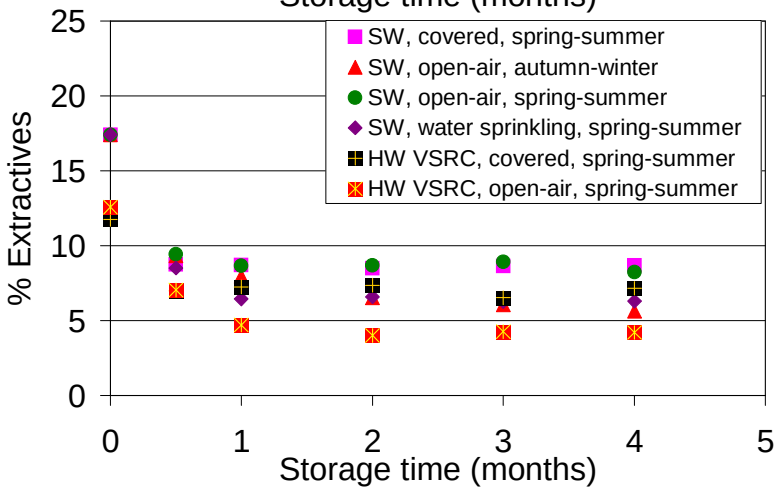
Process specifications (thermoconversion)	
Cl	**< 0.1 %**
S	**< 0.2 %**

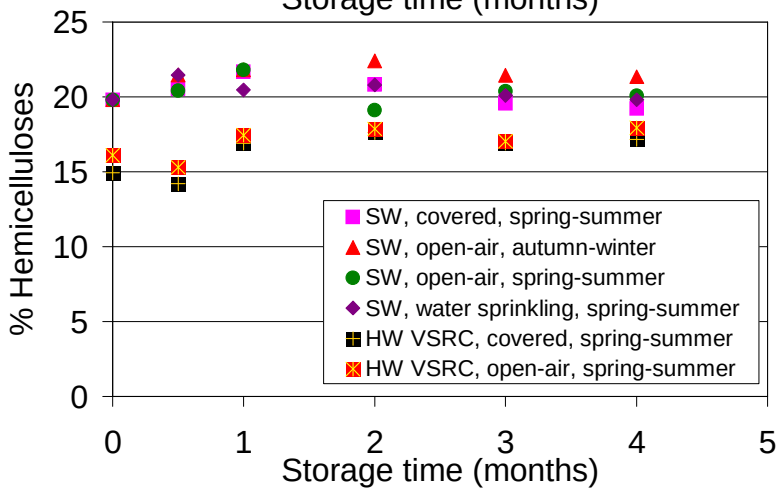
- ✓ **Process specifications respected**
- ✓ **No impact of storage on S content**
- ✓ **Covered storage difficult Cl removal**
- ✓ **No lixiviation of Cl**

Chemical composition



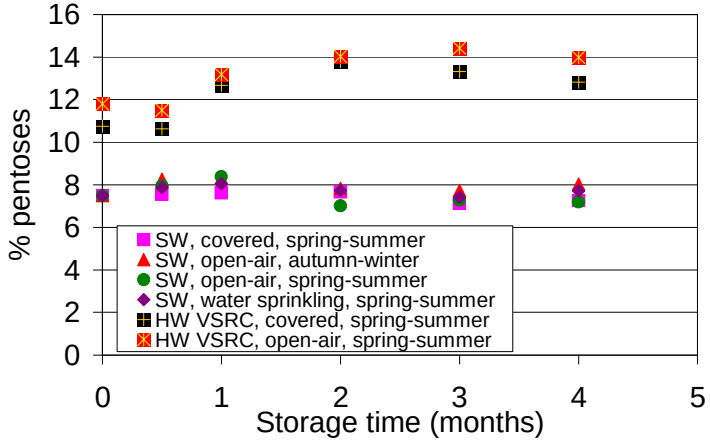


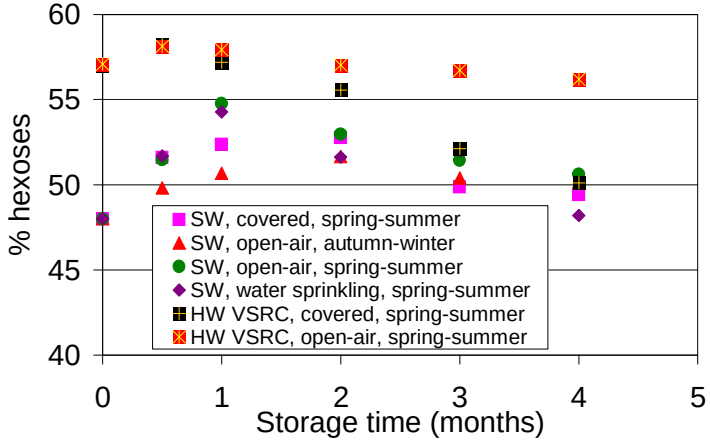




- ✓ **Important reduction of extractives artificially increases lignin and polysaccharides fractions**
- ✓ **Covered storage detrimental to extractives removal, while water-sprinkling favors it**
- ✓ **Polysaccharides degradation observed for covered storage**

Chemical composition

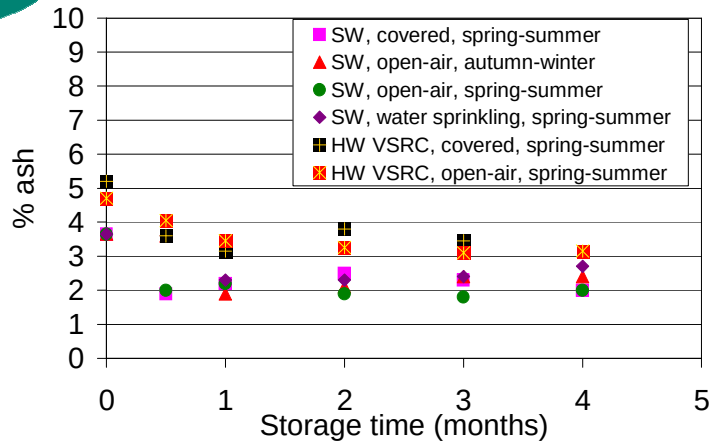


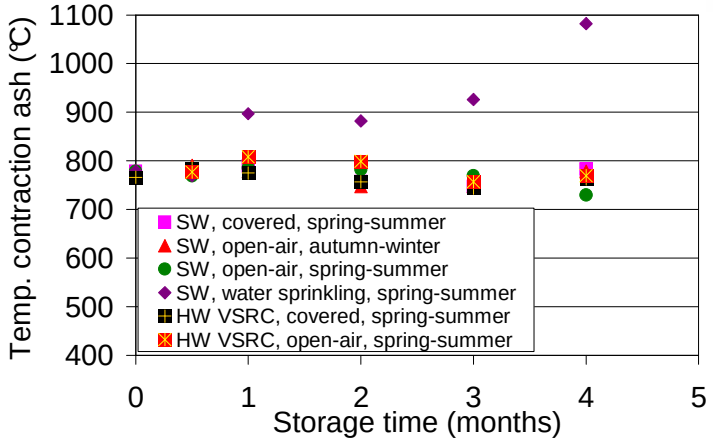


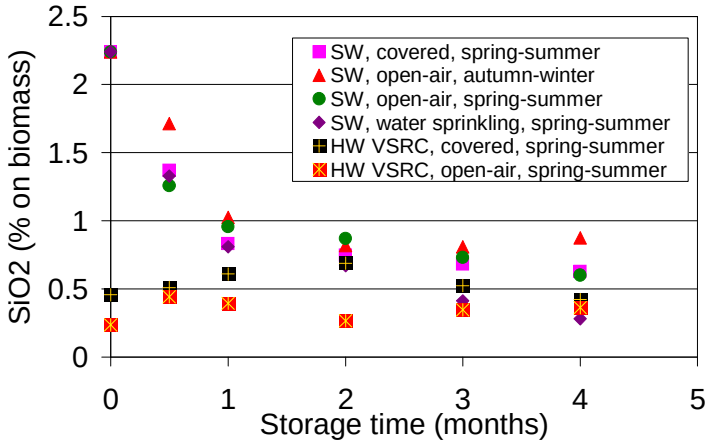
- ✓ Sugars content artificially increased by high amount of extractives removed during storage for most of the cases
- ✓ Important degradation of hexoses fraction of HW stored under coverage
- ✓ Some lixiviation of hexoses due to water sprinkling observed

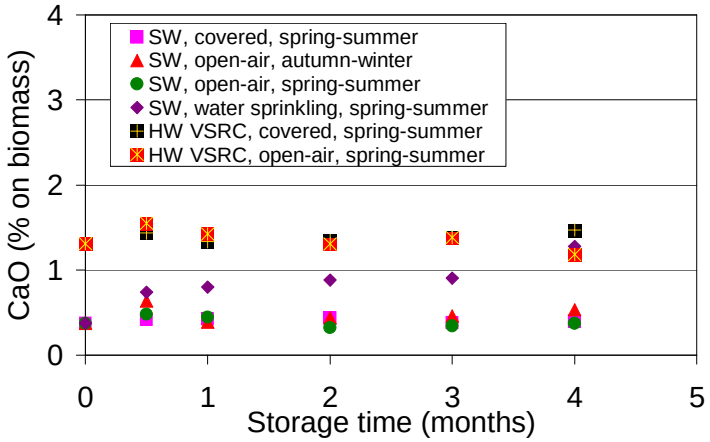
Process specifications (bioconversion)	
Hexoses	**High content Easy to fermentate**
Pentoses	**Low content Hard to fermentate**

Ash content and composition



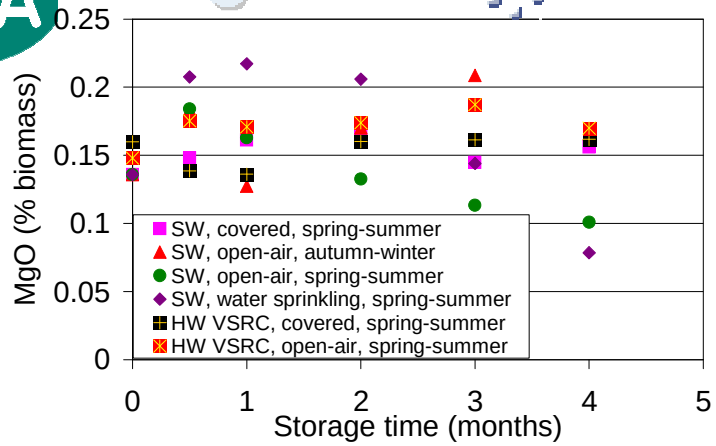


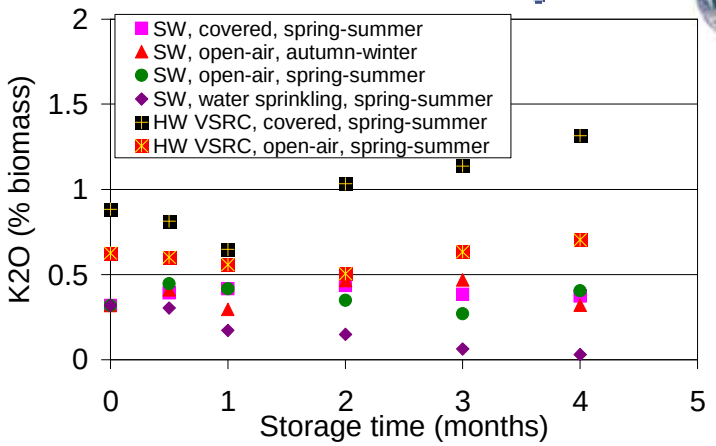


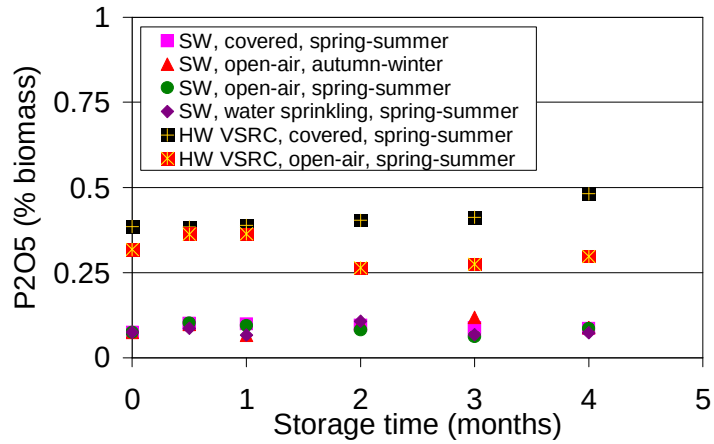


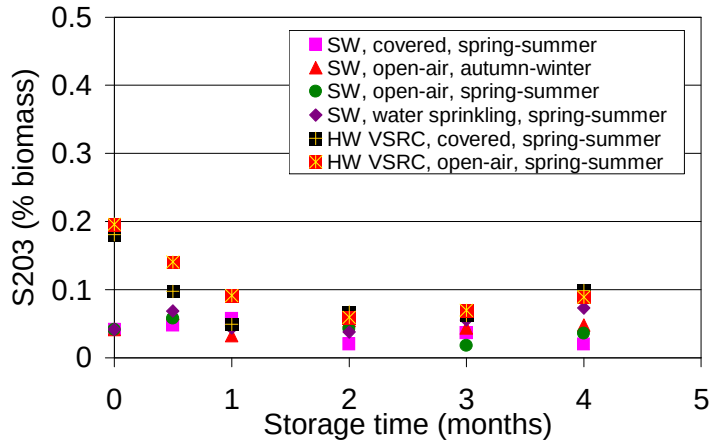
- ✓ **No important quantitative reduction of ash content by water-sprinkling, but qualitatively, the removed elements strongly impact the ashes melting behaviour**
- ✓ **Storage beneficial to SiO2 removal for SW (needles). Similar effect on agricultural biomass ?**
- ✓ **CaO increases during water-sprinkling : related to water quality ?**

Ash content and composition



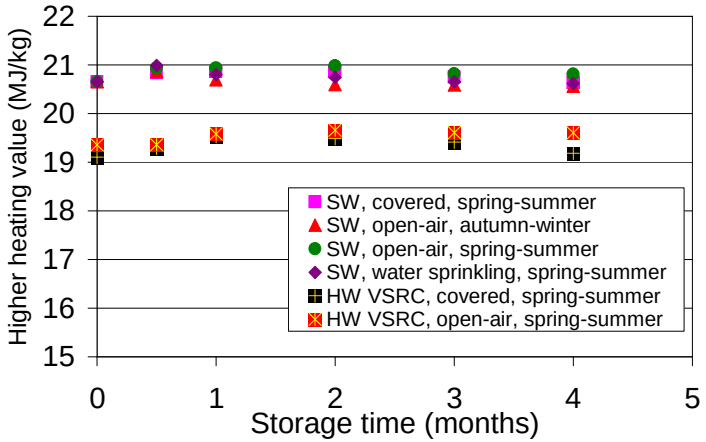






- ✓ **Degradation of organic fractions (hexoses, extractives, etc) artificially increase inorganic contents**
- ✓ **MgO and K2O affected by lixiviation (water-sprinkling or high precipitation)**
- ✓ **P2O5 not removed during covered storage**
- ✓ **S2O3 (residual in ash) decreased during storage**

Heating value



- ✓ Higher HHV values for SW compared to HW
- ✓ Small changes caused by storage
- ✓ Long storage under coverage can be detrimental to HHV

Conclusions

- ✓ **Biomass humidity evolution depends on climatic conditions, storage methods and wood species**
- ✓ **Forestry biomass in adequacy with process requirements for C and H but not for O (modulable by water) and N**
- ✓ **Reduction of extractives artificially increases lignin and saccharides fractions during storage**
- ✓ **Important saccharides (including hexoses) degradation observed for covered storage**
- ✓ **Water-sprinkling strongly impacts the ashes melting behaviour (removal of selected elements); importance of water for CaO content control…**
- ✓ **Storage beneficial to SiO2 removal for SW (needles). Can a similar effect take place on agricultural biomass ?**
- ✓ **Degradation of organic fractions (hexoses, extractives, etc) artificially increase inorganic contents**
- ✓ **Almost no impact of storage on HHV**

Acknowledgments

- ✓ **ADEME (financial support of REGIX project)**
- ✓ **Project partners and steering committee members**
- ✓ **Members of WG “biomass quality x conversion processes”**
- ✓ **Organizing committee of Bioenergy II conference**
- ✓ **Conference participants**